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Structural, Optical and Electrical Properties of Green Synthesis CdO Nanoparticles and Its Ag/CdO/P-Si Junction Diode Fabricated Via JNS Pyrolysis Technique

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Abstract: CdO nanoparticle is synthesized using green tea extract as solvent by microwave irradiation method. Its crystalline structure is confirmed by the well define peaks of powder XRD study. The surface morphology is analyzed by SEM and TEM spectrograph. The percentage composition of cadmium present in the synthesized material is confirmed by EDS study also presence of various functional groups is analysis using FTIR spectrum. The band gap energy of composed material is calculated with the help of cut off peak of diffused reflectance spectrum of UV study. The thermal conductance of the substance is increasing with increasing the temperature. The good rectifying character of CdO is explained with the help of I-V character study.

Keywords: Nanoparticle, Photoluminescence, Conductivity, p-n junction diode

1. Introduction

Need of high quality nanoparticle is going on increasing in recent years. In the field of nano technology synthesis of metal nanoparticles is an active area for research scholars synthesizing of nano metal has an exponential application including imaging, diagnosis, drugs and therapeutics.

On this line nanoparticle of CdO is interesting particle which is n type semiconductor metal oxide with bandgap energy 2.5eV [1]. CdO nanoparticles possess promising character for electrical, optical and chemical application.

Large number of surface atom present in the CdO nanoparticle is a reason for outstanding properties of CdO nanoparticles. Despite of chemical and physical method are there for synthesis of nano particle discovery of those method there is a disservice of using toxic solvent, high energy consumption, hazard, products etc. On the other hand there is requisite need of environment friendly methods for syntheses of metal nano particles.

Upgrade the eco-friendly technology synthesis the metal nanoparticle are more wanted to increase their biological application. As today trends verities of green nanoparticles with well-defined Chemical composition size and morphology have been Synthesized by various methods and their applications in many areas have been explored [3, 4].

Use of plant extracts are due to the renewable nature, eco-friendly aqueous medium and mild reaction condition. The green technology consists of three steps 1. Selecting biocompatible and nontoxic solvent medium 2. Selecting environmentally reducing agent 3. Selecting nontoxic substance for stabilization of the nanoparticle.

Various works has been done using plant extracts to promote reduction of metal nanoparticle due to the presence of some phytochemicals. The main phytochemicals responsible have been identified as terponoids, flavones, ketones, aldehydes, carboxylic acids through FTIR spectroscopy studies. The main water-soluble phytochemicals are flavones, organic acids and quinoes, which are responsible for immediate reduction [5, 6].

An accepted scientific consensus emanating from several scientific investigation is that tea (camellia sinensis) contains anti-oxidant polyphenol, including flavonoids, and catechains all of which sewerage the dangerous free radicals in the body and thus prevent the progress of various diseases.

Since CdO nano particle has very good application in solar cell, phototransistor, catalyst, gas sensor, optoelectronic device etc. This paper delt with the change this property due to green synthesis technology using green tea extract CdO nanoparticle is prepared by microwave irradiation method which is simple and time saving method for synthesizing nano particle.

2. Experimental Conditions

2.1 Material and Methods

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Solution is prepared using cadmium chloride Merck grade and green tea powder from market, For Camellia sinensis extract 1g of leafs was placed in 50ml of boiling water and steared using magnetic stirrer for 30 minutes. The solution of camellia extract is filtered. 0.1 mole of cadmium chloride is dissolved in 25ml of camellia extract. The solution is stirred with the help of magnetic stirrer for 4 hours continuously and left undisturbed the precipitate of CdO deposited at the bottom. The precipitate is collected and washed with distilled water for several time. Until extract turns in to white product then it is dried using microwave at frequency 2.45Hz for 5 minutes continuously.

The synthesized CdO nanopowder were deposited on the (100) p-Si wafer by jet nebulizer spray pyrolysis (JNSP) technique to create P-N junction. The P-N junction formation before p-Si wafer chemically cleaned because to remove dust, grease and metallic impurities from the surface. The p-Si wafer cleaning process are attentively carried out as follows:

- The p-Si wafer was placed for 10min in boiling acetone and ethanol.
- The piranha solution (H_2O_2 +H_2SO_4 in ratio of 2:1) using to removing the organic residues and metallic impurities are left at the surface.
- The p-Si wafer native oxide layer removed using HF + H_2O (1:10) solution.
- The p-Si wafer was rinsed thoroughly DI water after each cleaning step.

The cleaned (1x1cm) p-Si wafer placed on the JNSP setup sample holder. The spray solution prepared by 100 mg of synthesized CdO nanopowder is mixed with 100 ml of 2-propanol at constant stirring for 1 day. After the colloidal solution was deposited on the p-Si wafer at 150ºC. Then silver paste (ELTEC Corporation) was used to make the better ohmic contact at both side. The fabricated device for dried 5 hours at room temperature. The fabricated device schematic diagram shown in Fig. 1.

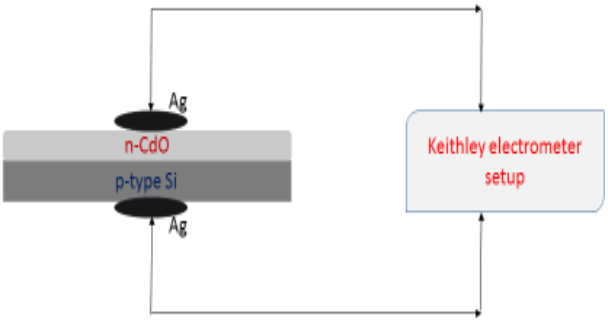

Fig 1. Device structure of Ag/n-CdO/p-Si junction diode

3. Characterization

XRD studies revels the micro structure of a sample. The average crystalline size is calculated using Scherer's formula d=kλ/βcosθ. Where d is the mean crystalline size k is grain shape dependent constant (0.9) λ is wave length of the incident beam, θ is a Bragg reflection angle and β is full width half maximum (FWHM) of the main peak. To investigate the surface morphology of the sample SEM, energy dispersive X-ray (EDX) analysis was carried out with JEOL56000LV microscope at an accelerating voltage of 10Kv. Fourier transform infrared spectroscopy (FTIR) spectrum were recorded using Bio-Rad spectrometer (Mod FTS-7) in KBr matrix in the range 400-1000cm^{-1}. Diffused reflectance spectroscopy (DRS) spectra were recorded on a Perkin Elmer UV-Vis DRS spectrometer. The luminescence character is analyzed using Photoluminescence (PL) spectra with spectroflurometer.

4. Results and Discussion

4.1 X-ray diffractometer analysis

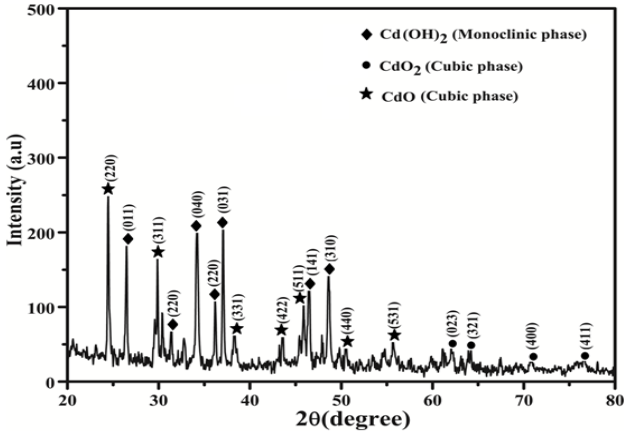

Fig 2. XRD spectrum of CdO nanoparticle

Powder X-ray diffraction pattern of CdO nano particle synthesis using green tea extract is displayed in Fig 2. The strong peaks observed at 27˚, 32˚,34˚,36˚, 36.5˚, 46˚ and 49˚ corresponding to the (011), (220), (040), (220), (031), (141), (310) planes respectively consist of cd(OH)$_2$ monoclinic JCPDS (CARD NO71-2137). Also the strong peaks observed at 25˚, 30˚, 37˚,44˚,46˚,51˚,56˚ corresponding to (220), (311), (331), (422),(511), (440), (531) planes respectively corresponds to cubic phase of CdO with JCPDS(ARD NO 01-104). In addition to it sharp peaks at 63˚, 64˚,71˚,77˚ corresponding to (023), (321), (400), (411) planes indicate the trace of CdO_2 in cubic phase JCPDS (CARD NO 39-1221) The sharp peaks in the XRD spectrum is a sign of good crystalline structure of CdO nanoparticle. The crystalline size D of the synthesized CdO nanoparticle is calculated using Scherre's formula [7],

$$D=\frac{0.9\,\lambda}{\beta cos\theta}$$

Where D- crystalline size, λ – wavelength of X-ray used, β – bordering of diffraction line measured at a half its maximum intensity and θ is the angle of diffraction. The crystalline

size of the synthesized CdO particle is 41nm. On the basis of above said data the synthesized material is mainly formed by a mixed cadmium hydroxyl carbon compound $cd(OH)_{2-x}(CO_3)_x$. Also CdO_2 nanoparticle might play an important role in the formation of CdO nanoparticle.

4.2 SEM analysis

Scanning electron microscopy analysis of green tea synthesized CdO nanoparticles shown in the Fig 3. The result shows that rod shape structure agglomeration of the crystal. The particle size of 2µm is shown in the Fig 2 A and also 1 µm particle size on the other phase. 0.5 µm and 1 µm on the other phase.

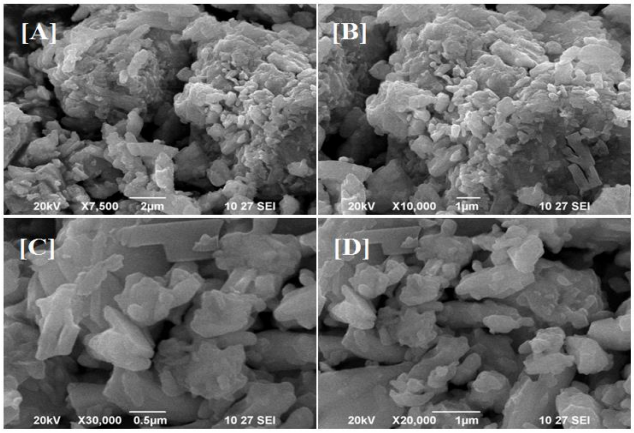

Fig 3. SEM image of green CdO nanoparticle

4.3 TEM analysis

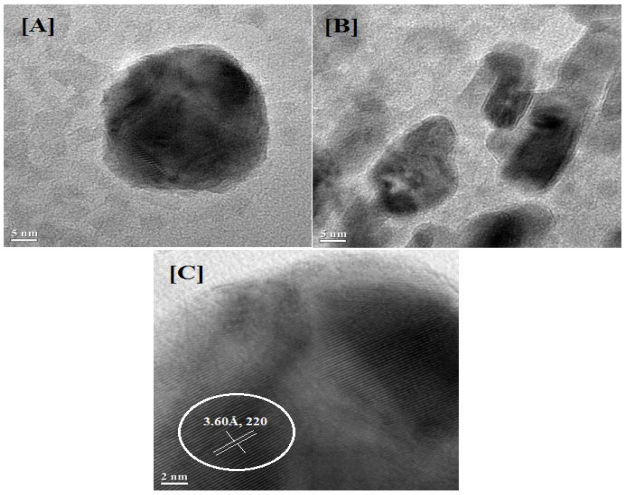

Fig 4. TEM image of green CdO nano particle.

Fig 4(a-d) shows the TEM micrographs of synthesized CdO nanoparticle. Inside Fig 3. A shows the corresponding SAED patterns. The image of HR-TEM shows spherical like morphology with average particle size 5nm. The particle are spherical and elliptical in shape not like those reported by Dong etal. [8]. The HR-TEM reveals the distinct crystalline domains in which the lattice fringe spacing of 3.60Å can be indexed to the (220) plane of CdO phase.

4.4 UV-VIS DRS spectrum

The optical properties of the of the synthesized CdO nano particle have been investigated. The enhanced performance of photo catalyst CdO nanoparticle is shown in the Fig 5. The CdO nanoparticle shows the reflectance edge at 240nm after that the reflectance is goes on increases gradually. This is due to the n-π^* transition of electrons at this wave length the optical cut off edge was 240nm and the corresponding band gap is around 2.18eV. It is expected that these CdO nanoparticle can be used as photo catalyst.

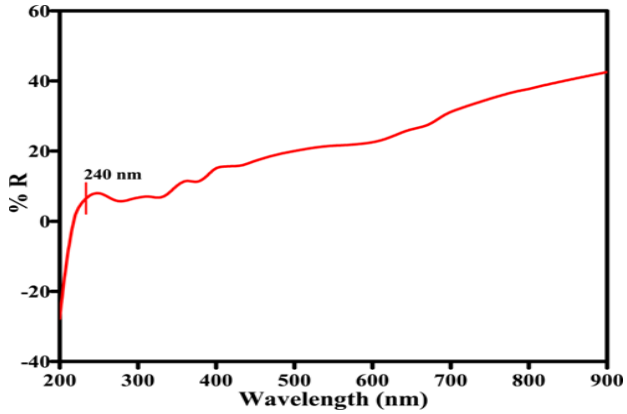

Fig 5. UV-DRS spectrum of green CdO nanoparticle.

4.5 EDS analysis

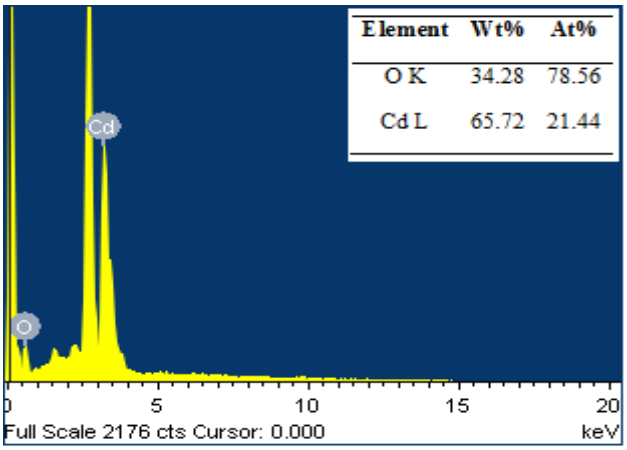

Fig 6. EDS spectrum of green CdO nano particle.

To identify and differentiate the chemical composition of the synthesized nano material it is subjected to EDS measurement which is shown in the Fig 6. In it the peak at 3.5KeV. And peak at 0.5KeV corresponds to cadmium and oxygen. The presence of cadmium and oxygen ions in CdO

and atomic percentage are found to be 21.44% and 78.56% respectively.

4.6 Photoluminescence studies

Photoluminescence spectra of a synthesized CdO nano particle is shown in the Fig 7. The spectra show the strong emission peak in 468nm, 480nm and weak emission in554nm. The sample is stimulated by the xenon light of wave length 407nm. Usually, emission band in UV and visible fields are observed in fluorescence spectrum of Cadmium Oxide (CdO) nanoparticles. The peak at 463nm which is in UV region corresponds to the cadmium oxide which is called edge band emission or excitation transmission. The peak in visible region is due to the recombination of holes resulted from photon emission with charge ionization in inherent deficiencies such as oxygen blank space, inter-lattice cd and or impurities. The emission spectrum is blue shifted. This blue shift due to the nano crystalline nature of the material [9]. Blue emission can be considered as direct recombination of conducting electron in Cd3d band and hole in O2p valence band. [10, 11]

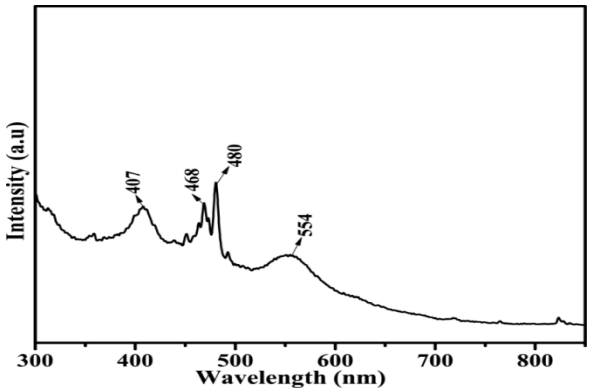

Fig 7. Photoluminance spectrum of green CdO nanoparticle.

4.7 Conductivity measurements

The electrical conductivity of the CdO nanoparticle are calculated by the following formula,

$$\rho = \left(\frac{I}{V}\right) X \left(\frac{l}{A}\right) s/cm$$

Where, I is the current, V is the applied voltage, l is the thickness and A is the cross sectional area of the sample. The conductivity of CdO nanoparticle measurement was done by Keithley 6571B High Resistance Meter and Electro meter using Two Probe - Setup. With constant voltage the temperature is varied from 30˚C to 130˚C the current is measured, the typical I-V characteristics of the sample under test to record at different temperatures are shown in Fig. 8 and it is found that the current changes linearly with temperature. At higher temperature the sample behave nonlinearly it tend towards non-ohmic behaviour. Fig. 9 shows the variation of electrical conductance as a function of the temperature of green CdO nano particle. It shows that the conductivity increases with the temperature. The average conductivity of CdO nano particle was found to be 1.4x10-4 S\cm. This suggests that the thermally activated behaviour of conductivity has been confirmed. It is also suggested that the thermal curling affects the chain alignment of the material which leads to the increase of conjugation length and which in turn brings about the increase in conductivity. Also, there will be molecular rearrangement on heating, which makes the molecules favourable for electron delocalization [12, 13].

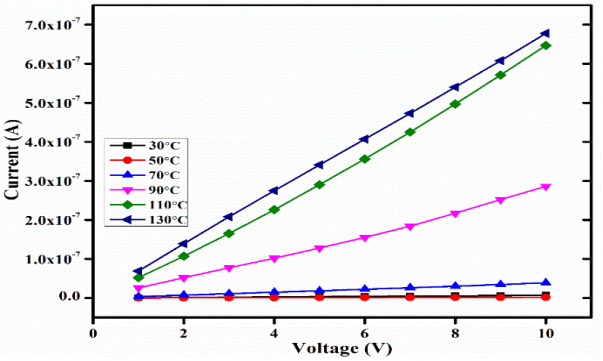

Fig 8 I-V Characteristics of CdO nanoparticle.

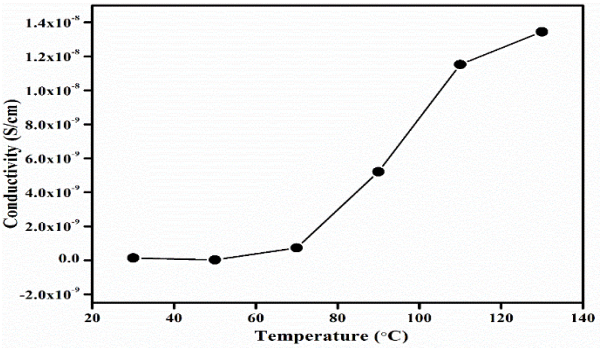

Fig 9. Conductivity of CdO nanoparticle.

4.8 Current voltage measurement

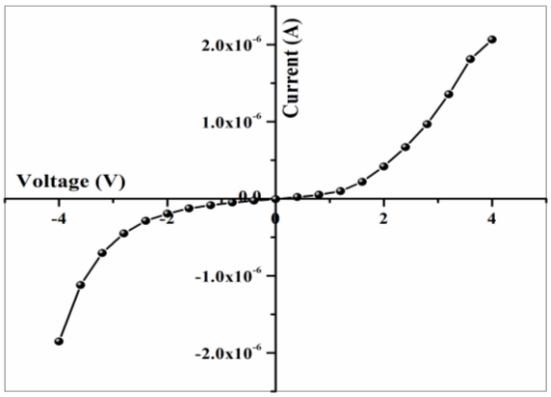

Fig 10. I-V character of CdO Scotty diode.

Current voltage (I-V) measurement of CdO nanoparticle was carried out at room temperature with an applied voltage range from -4v to +4v. The forward and reverse bias I-V characteristics of CdO nanoparticle is shown in the Fig 10. The ln(J) versus voltage characteristic shown in Fig 11. The obtain I-V characteristics exhibits good rectifying with the nonlinear nature of CdO diode. This nonlinear is due to the semiconductor behavior of the component and hence used in electronic device [13-15].

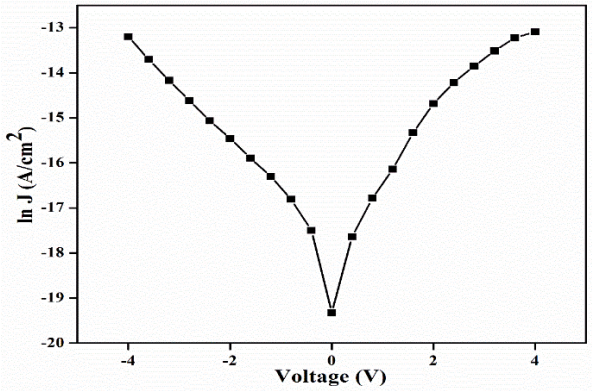

Fig 11. ln J versus Voltage character of CdO nanoparticle

5. Conclusion

CdO nanoparticle is synthesized using green tea extract by microwave irradiation method. The structural morphology was studied with XRD, FTIR, SEM, TEM and EDS study. The crystalline property of the substance is confirmed by the sharp peak in powder x-ray diffraction study also the presence of CdO, CdO_2, $Cd(OH)_2$ is confirmed which due to the green tea extract. The well define structure of rod shape is shown in the SEM result. The particle size of 5nm is imaged in the TEM analysis. The percentage composition of 21.44% and 78.9% of cadmium and oxygen is found out in the EDS analysis. The CdO nanoparticle shows good optical behavior with cut off wave length 240nm. Thus it is a good photocatalytic. The thermal conductance of the substance is increasing with increasing the temperature. The green tea synthesis CdO nano material shows very good rectifying property in the I-V characteristic graph which shows the grown material possess semiconducting properties which can be utilized for electronic devices.

References

[1] T. Prakash, G. Neri, E. Ranjith Kumar, A comparative study of the synthesis of CdO nanoplatelets by an albumen-assisted isothermal evaporation method, Journal of Alloys and Compounds 624 (2015) 258–265.

[2] S. Mukerjee, V. Sushima, S. Patra, A. K. Barvi, M. P. Bhadra, B. Sredhar and C. R. Patra, Green chemistry approach for the synthesis and stabilization of Biocompatible gold Nanoparticles and their potential application cancer therapy, Nanotechnology 23 (2012) 455103 (13pp).

[3] J. Yu, D. Vu, H. N. Guan, C. Wang, L. K. Huang and D. F. Chi, Facileone –step green synthesis of gold nanoparticle using citrus maxima Aqueous Extracts and its Catalytic Activity Materials letters 116 (2016) 110-112.

[4] P. K. Azandahi and J. Moghaddam, Green sythesischaracterization and physiological stability of Gold Nanoparticals from stachys lavonduliolia vahl extract particuology. 19 (2015) 22-26

[5] D. Nath, and P. Banerjee, Green Nanotechnology-A New Hope for Medical Biology. Environmental Toxicology and Pharmacology, 36 (2013) 997-1014.

[6] S. Iravani, Green Synthesis of Metal Nanoparticles Using Plants. Green Chemistry, 13 (2011) 2638-2650.

[7] K. Mohanraj, D. Balasubramanian, J. Chandrasekaran, B. Babu, Structural, morphological, optical and electrical properties of nail-shaped CdO nanoparticles synthesized by chemical route assisted microwave irradiation method for P–N junction diode application, J Mater Sci: Mater Electron, (2017) pp 1–11.

[8] W. Dong and C. Zhu, Optical properties of surface-modified CdO nanoparticles, opt. Mater 22 (2003) 227-233.

[9] S. K. Apte, S. N. Garaje, G. P. Mane, A. Vinu, S. D. Naik , D. P. Amalnerkar , and B. B. Kale, A Facile Template-Free Approach for the Large-Scale Solid-Phase Synthesis of CdS Nanostructures and Their Excellent Photocatalytic Performance small, 7 (2011) 957–964.

[10] A. Heidari and C. Brown, Study of Composition and Morphology of Cadmium Oxide (CdO) Nanoparticles for Eliminating Cancer Cells, J Nanomed Res, 2(5) (2015) 00042.

[11] R. Bakkiyaraj, G. Bharath, K. Hasini Ramsait, Ahmed Abdel-Wahab, Edreese H. Alsharaeh, Shen-Ming Chen and M. Balakrishnan, Solution combustion synthesis and physicochemical properties of ultrafine CeO2 nanoparticles and their photocatalytic activity, RSC Adv., , 6 (2016) 51238–51245.

[12] S. Ashokan, V. Ponnuswamy, P. Jayamurugan, Fabrication and characterization PANI/CuO hybrid films by nebulizer spray pyrolysis technique for diode applications, Optik - International Journal for Light and Electron Optics 126 (2015) 2591-2595.

[13] M. Raja, J. Chandrasekaran, M. Balaji, B. Janarthanan, Impact of annealing treatment on structural and dc electrical properties of spin coated tungsten trioxide thin films for Si/WO3/Ag junction diode, Materials Science in Semiconductor Processing 56 (2016) 145–154.

[14] Dhananjaya, J. Nagarajua, S. B. Krupanidhi, Investigations on magnetron sputtered ZnOthin films and Au/ZnOSchottky diodes, Physica B 391 (2007) 344–349.

[15] A. Kobayashi, H. Ishikawa, K. Amano, M. Satoh, and E. Hasegawa, Electrical Conductivity of Annealed Polyaniline, J. Appl. Phys. 74 (1993) 296-299.